CLAIMS

WHAT IS CLAIMED IS:

1. Diformatodimethylsilane.

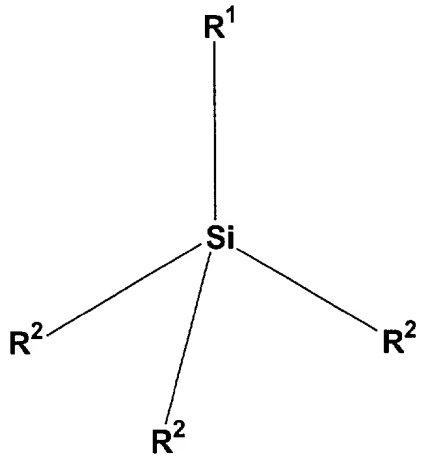
2. A method of synthesizing diformatodimethylsilane by a method comprising:

$2M^1(OOCH) + (CH_3)_2SiCl_2 \rightarrow (CH_3)_2Si(OOCH)_2 + 2\,M^1Cl$

wherein M^1 is selected from the group consisting of Na (sodium), K (potassium) and Ag (silver).

3. An organosilicon precursor useful for producing porous, low-dielectric constant, SiOC thin films, wherein the organosilicon precursor comprises at least one cleavable organic functional group.

4. The organosilicon precursor according to claim 3, wherein the organosilicon precursor comprises a composition selected from the group consisting of:

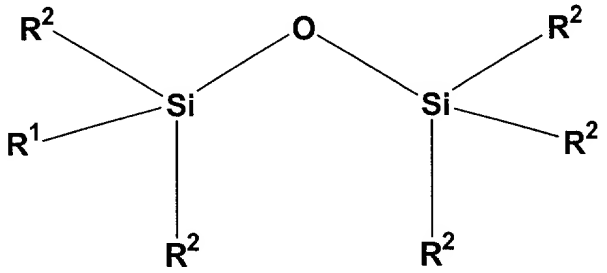


Formula 1

wherein

R^1 is a cleavable organic functional group, selected from the group consisting of C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; ligand X as described hereinbelow, and ligand Y as described hereinbelow; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinbelow, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 alkoxy, aryl, perfluoroaryl and C_2 to C_6 alkylsilane; and



Formula 2

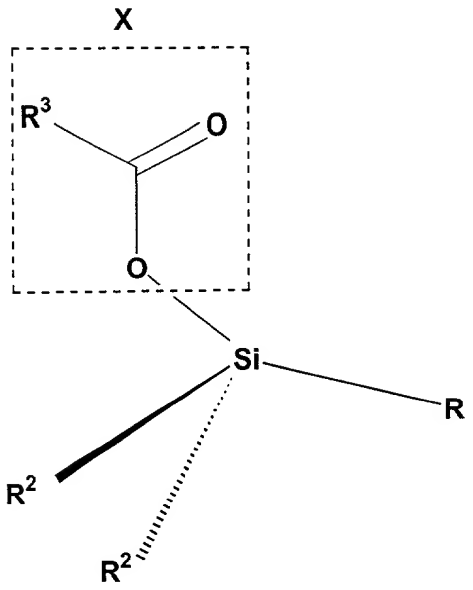
wherein

R^1 is a cleavable organic functional group, selected from the group consisting of C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; ligand X as described hereinbelow, and ligand Y as described hereinbelow; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinbelow, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane.

5. The organosilicon precursor according to claim 3 wherein the organosilicon precursor further comprises at least one alkyl group.

6. The organosilicon precursor according to claim 5, wherein the organosilicon precursor comprises a composition selected from the group consisting of:



Formula 3

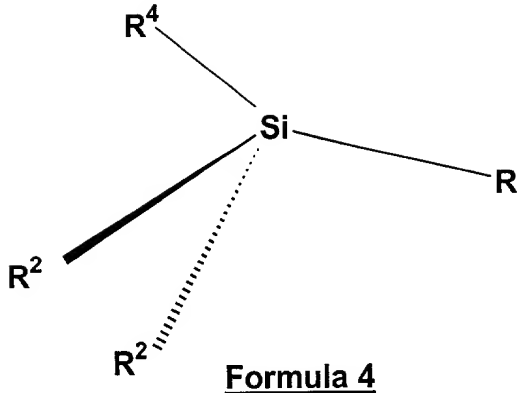
wherein

ligand X is a cleavable organic functional group as depicted in Formula 3;

R^3 is selected from the group consisting of: H, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 carboxylate, aryl and perfluoroaryl;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



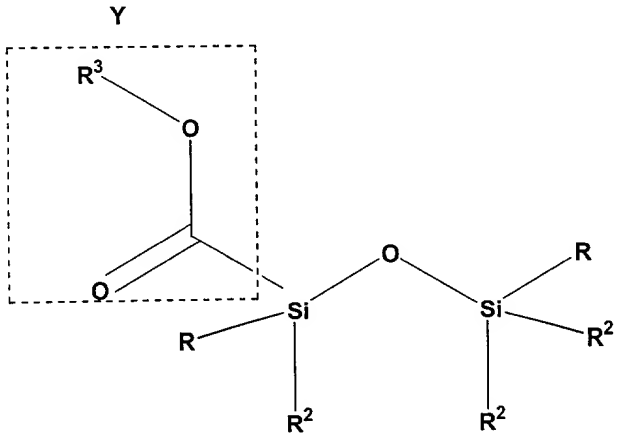
Formula 4

wherein

R^4 is a cleavable organic functional group selected from the group consisting of: C_2 to C_6 alkene, and C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; C_1 to C_6 alkylsilane, and ligand Y as described hereinbelow;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



Formula 5

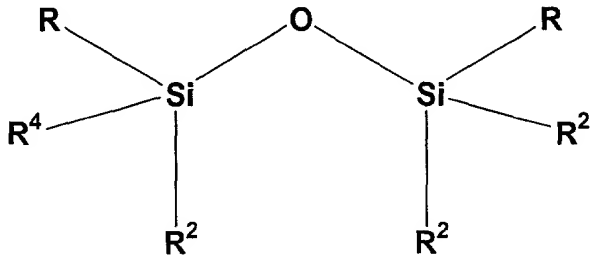
wherein

ligand Y is a cleavable organic functional group as depicted in Formula 3;

R^3 is selected from the group consisting of: H, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl aryl; perfluoroaryl and C_1 to C_6 carboxylate;,

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



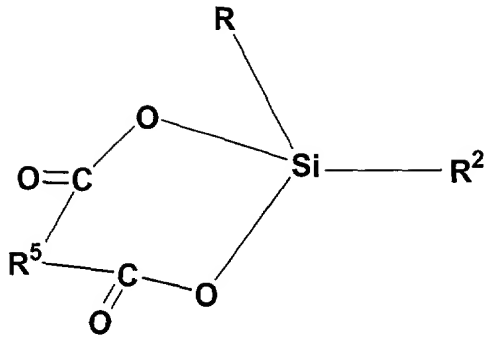
Formula 6

wherein

R^4 is a cleavable organic functional group selected from the group consisting of: C_2 to C_6 alkene, and C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; C_1 to C_6 alkylsilane, and ligand Y as described hereinabove;

each of R is same or different and each of R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinabove, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane; and



Formula 7

wherein

R^5 is optional and may be selected from the group consisting of C_1 to C_2 alkyl;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinabove, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane.

7. The organosilicon precursor according to claim 3, wherein the organosilicon precursor is di(formato)dimethylsilane.

8. The organosilicon precursor according to claim 5, wherein the organosilicon precursor is di(formato)dimethylsilane

9. The organosilicon precursor according to claim 3 wherein the organosilicon precursor is selected from the group consisting of: di(formato)methylsilane; di(formato)dimethylsilane; tri(formato) methylsilane; 1,3-dimethyl-1,1,3,3- tetra(formato)disiloxane; 1,3-di(formato)-1,3-disiloxane; diethyldimethylsilane; triethylmethylsilane; 1,1,3,3-diethyl-1,3-dimethyldisiloxane; di-t-butylsilane; 1,3-di-t-butyl-1,1,3,3-tetramethyldisiloxane; di-isopropylsilane; 1,3-di-isopropyl-

1,1,3,3- tetramethyldisiloxane; di-isobutylsilane; 1,3-isobutyl-1,1,3,3,-tetramethyldisiloxane; t-butylsilane; 1,3-di-t-butyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,3-dimethyldisiloxane; 1,3-divinyl-1,1,3,3-tetramethyldisiloxane and 1,3 divinyl-1,3-dimethyldisiloxane.

10. The organosilicon precursor according to claim 5 wherein the organosilicon precursor is selected from the group consisting of: di(formato)methylsilane; di(formato)dimethylsilane; tri(formato)methylsilane; 1,3-dimethyl-1,1,3,3- tetra(formato)disiloxane; 1,3-di(formato)disiloxane; 1, 3-diethynyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,3-dimethyldisiloxane; 1,3-divinyl-1,1,3,3-tetramethyldisiloxane and 1,3-divinyl-1,3-dimethyldisiloxane.

11. A CVD process for producing a porous, low dielectric constant, SiOC thin film on a substrate, from at least one organosilicon precursor comprising at least one cleavable, organic functional group that upon activation, rearranges, decomposes and cleaves as a highly volatile liquid or gaseous by-product.

12. The CVD process according to claim 11, wherein the CVD process comprises:

placing the substrate in a chemical vapor deposition apparatus,

introducing at least one vaporized organosilicon precursor comprising at least one cleavable organic functional group into the apparatus;

transporting the organosilicon vapor into a chemical vapor deposition zone containing a substrate, optionally using a carrier gas to effect such transport;

contacting the organosilicon vapor with the substrate under chemical vapor deposition conditions to deposit a thin film comprising an organosilicon composition;

annealing the organosilicon thin film to produce a porous, SiOC, low dielectric constant thin film.

13. The CVD process according to claim 11, wherein the organosilicon precursor further comprises at least one alkyl group.

14. The CVD process according to claim 12, wherein the porous SiOC thin film comprises between about 1 and 20 percent carbon.

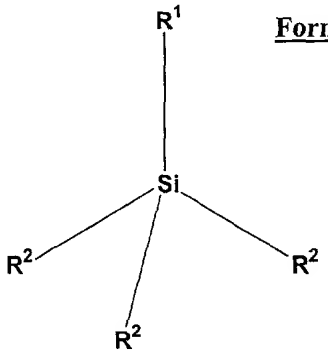
15. The CVD process according to claim 12, wherein the porous SiOC thin film comprises between about 1 and 20 percent carbon.

16. The CVD process according to claim 12, wherein the porous SiOC thin film comprises between about 1 and 20 percent carbon.

17. The CVD process according to claim 12 wherein the CVD process is PECVD.

18. The CVD process according to claim 13, wherein the alkyl group is selected from the group consisting of C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl.

19. The CVD process according to claim 12, wherein the organosilicon precursor is selected from the group consisting of:

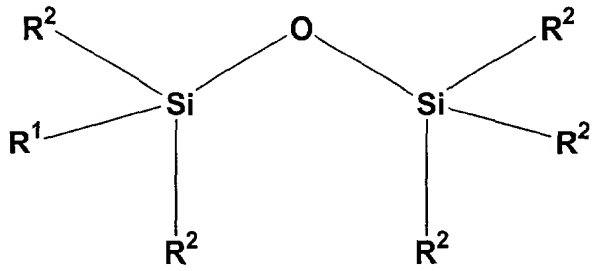


Formula 1

wherein

R^1 is a cleavable organic functional group, selected from the group consisting of C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; ligand X as described hereinbelow, and ligand Y as described hereinbelow; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinbelow, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 alkoxy, aryl, perfluoroaryl and C_2 to C_6 alkylsilane; and



Formula 2

wherein

R^1 is a cleavable organic functional group, selected from the group consisting of C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; ligand X as described hereinbelow, and ligand Y as described hereinbelow; and

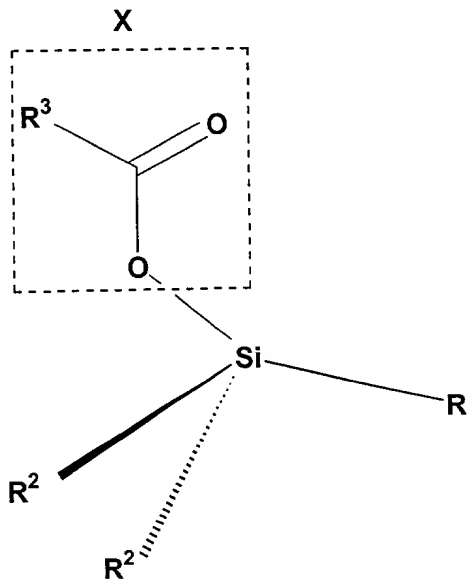
each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinbelow, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane.

20. The CVD process according to claim 12, wherein the organosilicon precursor is diformatodimethylsilane.

21. The CVD process according to claim 12, wherein the organosilicon precursor is selected from the group consisting of: di(formato)methylsilane; di(formato)dimethylsilane; tri(formato) methylsilane; 1,3-dimethyl-1,1,3,3- tetra(formato)disiloxane; 1,3-di(formato)-1,3-disiloxane; diethyldimethylsilane; triethylmethylsilane; 1,1,3,3-diethyl-1,3-dimethyldisiloxane; di-t-butylsilane; 1,3-di-t-butyl-1,1,3,3-tetramethyldisiloxane; di-isopropylsilane; 1,3-di-isopropyl-1,1,3,3- tetramethyldisiloxane; di-isobutylsilane; 1,3-isobutyl-1,1,3,3,-tetramethyldisiloxane; t-

butylsilane; 1,3-di-t-butyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,3-dimethyldisiloxane; 1,3-divinyl-1,1,3,3-tetramethyldisiloxane and 1,3 divinyl-1,3-dimethyldisiloxane.

22. The CVD process according to claim 13, wherein the organosilicon precursor is selected from the group consisting of:



Formula 3

wherein

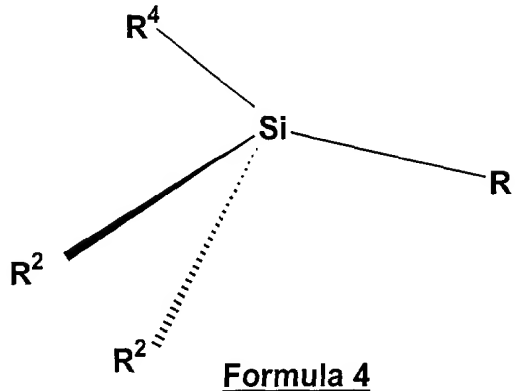
ligand X is a cleavable organic functional group as depicted in Formula 3;

R^3 is selected from the group consisting of: H, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl, C_1 to C_6 carboxylate, aryl and perfluoroaryl;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene,

C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



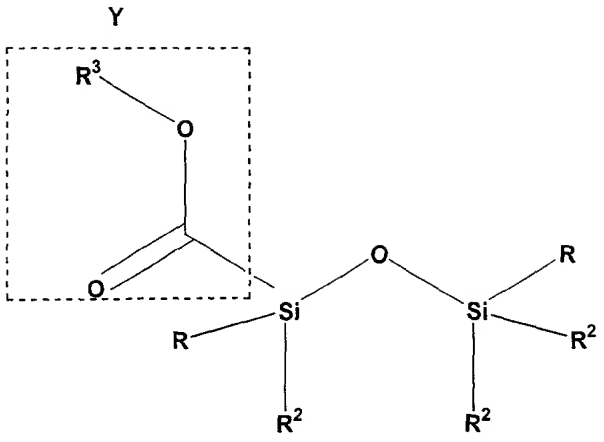
Formula 4

wherein

R^4 is a cleavable organic functional group selected from the group consisting of: C_2 to C_6 alkene, and C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; C_1 to C_6 alkylsilane, and ligand Y as described hereinbelow;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



Formula 5

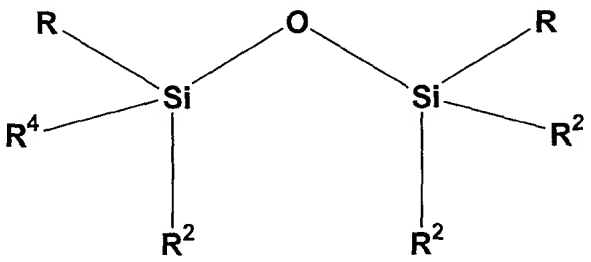
wherein

ligand Y is a cleavable organic functional group as depicted in Formula 3;

R^3 is selected from the group consisting of: H, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl aryl; perfluoroaryl and C_1 to C_6 carboxylate;,

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinbelow, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane;



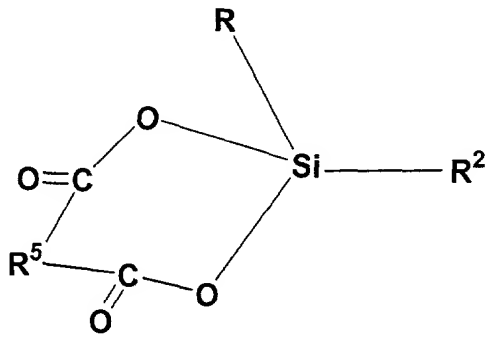
Formula 6

wherein

R^4 is a cleavable organic functional group selected from the group consisting of: C_2 to C_6 alkene, and C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_6 alkyl, C_1 to C_6 perfluoroalkyl; C_1 to C_6 alkylsilane, and ligand Y as described hereinabove;

each of R is same or different and each of R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

each of R^2 is same or different and each of R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinabove, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane; and



Formula 7

wherein

R^5 is optional and may be selected from the group consisting of C_1 to C_2 alkyl;

R is selected from the group consisting of: C_1 to C_4 alkyl and C_1 to C_4 perfluoroalkyl; and

R^2 is selected from the group consisting of H, ligand X as described hereinabove, ligand Y as described hereinabove, C_2 to C_6 alkene, C_2 to C_6 alkyne, C_3 to C_4 allyl, C_1 to C_4 alkyl, C_1 to C_4 perfluoroalkyl, C_1 to C_6 alkoxy, aryl , perfluoroaryl and C_2 to C_6 alkylsilane.

23. The CVD process according to claim 13 wherein the organosilicon precursor is diformatodimethylsilane.

24. The CVD process according to claim 13 wherein the organosilicon precursor is selected from the group consisting of: di(formato)methylsilane; di(formato)dimethylsilane; tri(formato)methylsilane; 1,3-dimethyl-1,1,3,3- tetra(formato)disiloxane; 1,3-di(formato)disiloxane; 1, 3-diethynyl-1,1,3,3-tetramethyldisiloxane; 1, 3-diethynyl-1,3-dimethyldisiloxane; 1,3-divinyl-1,1,3,3-tetramethyldisiloxane and 1,3-divinyl-1,3-dimethyldisiloxane.

25. The CVD process according to claim 10, wherein the CVD process comprises more than one organosilicon precursor.

26. The CVD process according to claim 12, wherein the CVD process further comprises a process gas.

27. The CVD process according to claim 26, wherein the process gas is selected from the group consisting of: .CO_2, ethylene, acetylene, N_2O, O_2, H_2 and mixtures thereof.

28. The CVD process according to claim 12, wherein the organosilicon vapor comprises between 1 and 100 percent by volume of an organosilicon precursor vapor and between 1 to about 100 percent by volume of an inert carrier gas, based on the total volume of organosilicon precursor vapor and the inert carrier gas.

29. The CVD process according to claim 12, wherein the inert carrier gas is selected from the group consisting of argon and helium.

30. The CVD process according to claim 12, wherein the organosilicon vapor comprises between 1 and 100 percent by volume of an organosilicon precursor vapor, between 1 and 100 percent by volume of an inert carrier gas, and about 1 to 100 percent by volume of a co-reactant, based on the total volume of organosilicon precursor vapor, the inert carrier gas and the co-reactant.

31. The CVD process according to claim 12, wherein the inert carrier gas is selected from the group consisting of argon and helium.

32. The CVD process according to claim 30, wherein the co-reactant is selected from the group consisting of: .CO_2, ethylene, acetylene, N_2O, O_2, H_2 and mixtures thereof.

33. The CVD process according to claim 12, wherein the organosilicon composition retains between 50 to 95 percent of the original cleavable organic functional groups.

34. The CVD process according to claim 12, wherein the CVD conditions include a chamber temperature in the chamber in a range of from about 50°C to about 400°C.

35. The CVD process according to claim 12, wherein the CVD conditions include a chamber temperature in a range of between 250°C to about 350°C.

36. The CVD process according to claim 12, wherein the CVD conditions include a chamber pressure in a range of from about 500 mTorr to about 10 Torr.

37. The CVD process according to claim 12, wherein the CVD conditions include a chamber pressure of about 4 Torr.

38. The CVD process according to claim 12, wherein the CVD conditions include a single or mixed frequency RF power source.

39. The CVD process according to claim 12, wherein the annealing step further comprises an oxidizing or reducing gas.

40. The CVD process according to claim 12, wherein the-annealing step occurs under plasma-enhanced or oxygen assisted plasma conditions.

41. The CVD process according to claim 12, wherein the organosilicon thin film is annealed at a gradually increasing temperature profile to a temperature between 100°C and 400°C.

42. The CVD process according to claim 12, wherein the organosilicon thin film is annealed at a temperature of 400°C.

43. The CVD process according to claim 12, wherein the annealing step further comprises CO_2.

44. The CVD process according to claim 12, wherein the annealing step further comprises an oxidizing gas, a reducing gas or combinations thereof.

45. The CVD process according to claim 12, wherein the annealing step further comprises an oxidizing gas selected from the group consisting of: O_2, O_3, N_2O, NO and combinations thereof.

46. The CVD process according to claim 12, wherein the annealing step further comprises a reducing gas selected from the group consisting of H_2 or NH_3.

47. The CVD process according to claim 12, wherein the annealing step further comprises an inert gas selected from the group consisting of: He, Ar and combinations thereof.

48. The CVD process according to claim 12, wherein the microporous, low dielectric constant, SiOC thin film comprises between 5 and 99 percent porosity.

49. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises between 5 and 80 percent porosity.

50. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises between 5 and 70 percent porosity.

51. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises between 1 and 20 atomic percent carbon.

52. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises between 1 and 15 atomic percent carbon.

53. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises between 1 and 10 percent carbon.

54. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises a dielectric constant of less than 3.0.

55. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises a dielectric constant of less than 2.0.

56. The CVD process according to claim 12, wherein the microporous, low dielectric constant SiOC thin film comprises a dielectric constant of less than 1.5.

57. A porous, low dielectric constant thin film made by the process of claim 12.